US009434459B2

(12) **United States Patent**
Solari et al.

(10) **Patent No.: US 9,434,459 B2**
(45) **Date of Patent: Sep. 6, 2016**

(54) **THERMAL INSULATING BUSHING FOR PISTON FIRST STAGES**

(71) Applicants: **Franco Solari**, Chiavari (IT); **Alessandro Cigolini**, Casarza Ligure (IT); **Corrado Cominetti**, Cogorno (IT)

(72) Inventors: **Franco Solari**, Chiavari (IT); **Alessandro Cigolini**, Casarza Ligure (IT); **Corrado Cominetti**, Cogorno (IT)

(73) Assignee: **Johnson Outdoors Inc.**, Racine, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 133 days.

(21) Appl. No.: **14/207,874**

(22) Filed: **Mar. 13, 2014**

(65) **Prior Publication Data**

US 2015/0259057 A1 Sep. 17, 2015

(51) **Int. Cl.**
F16K 31/12 (2006.01)
B63C 11/22 (2006.01)

(52) **U.S. Cl.**
CPC ***B63C 11/2209*** (2013.01); *Y10T 137/0318* (2015.04); *Y10T 137/7793* (2015.04); *Y10T 137/7808* (2015.04)

(58) **Field of Classification Search**
CPC Y10T 137/2036; Y10T 137/7808; Y10T 137/7811
USPC 128/204.29, 205.24; 251/337
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,890,999	A *	6/1975	Moskow	137/505.25
4,230,140	A *	10/1980	Hart	137/81.2
5,190,030	A	3/1993	Semeia	
5,381,825	A *	1/1995	Garraffa	137/505.18
5,507,308	A *	4/1996	Chambonnet	137/81.2
5,685,297	A *	11/1997	Schuler	128/205.24
5,775,368	A *	7/1998	Morino	137/505.25
6,725,861	B1	4/2004	Semeia	
2002/0088495	A1*	7/2002	Semeia	137/505.25
2003/0221726	A1*	12/2003	Semeia	137/338
2005/0016537	A1	1/2005	Pedemonte	
2008/0105308	A1*	5/2008	Garraffa	137/505.18
2008/0236587	A1	10/2008	Semeia	
2011/0057138	A1*	3/2011	Maus et al.	251/357
2013/0266465	A1*	10/2013	Akita et al.	417/443

FOREIGN PATENT DOCUMENTS

EP	0 503 300	A2	9/1992
EP	0 811 549	A2	12/1997
EP	1200305	A1	5/2002
JP	2010-287337	*	12/2010

* cited by examiner

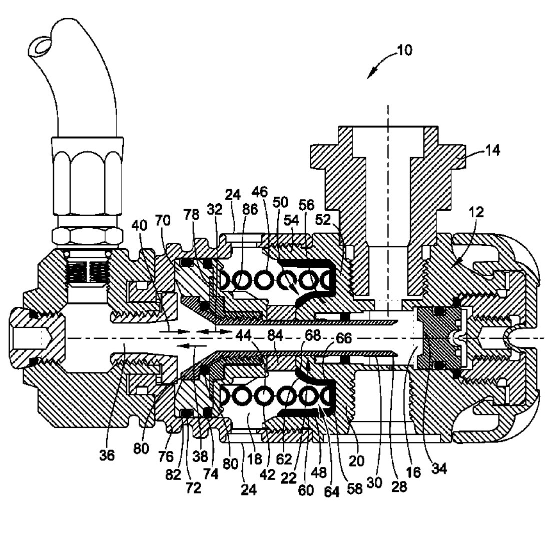
Primary Examiner — R. K. Arundale

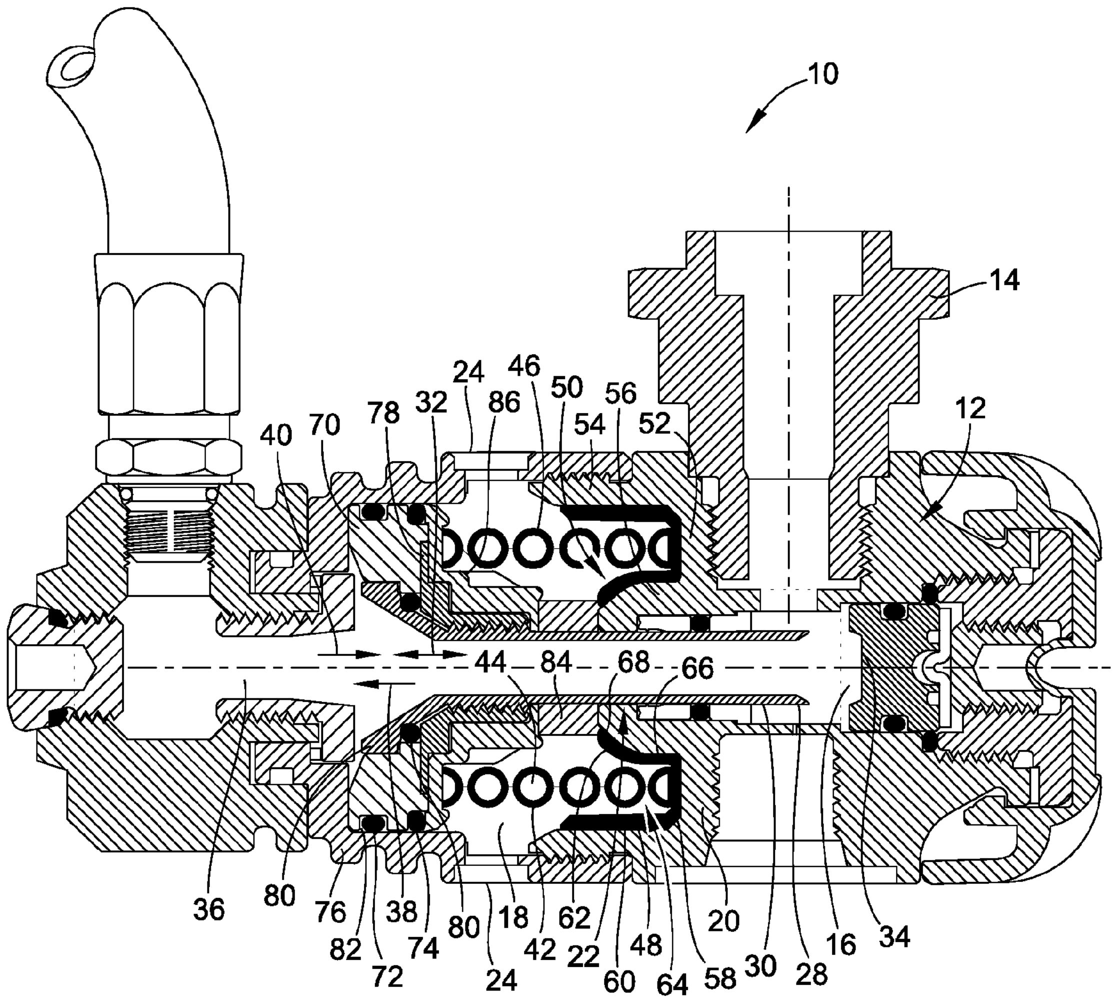
(74) *Attorney, Agent, or Firm* — Reinhart Boerner Van Deuren P.C.

(57) **ABSTRACT**

A first stage pressure regulator is provided. The regulator includes a valve body having an inlet and an outlet coupled by a pressure chamber. A pressure compensation chamber fluidly communicates with the surrounding water. A valve member is slidably carried by the valve body between an open state in which fluid is permitted to flow between the inlet and outlet and a closed state in which fluid is prevented from flowing between the inlet and outlet. The valve member has an expansion head that is operably acted upon by the surrounding water within the pressure compensation chamber to bias the valve member toward the open state. The regulator includes an annular insulating bushing within the compensation chamber that covers a portion of the valve body defining a portion of the pressure compensation chamber to insulate the valve body from the water within the pressure compensation chamber.

15 Claims, 1 Drawing Sheet




10
14
24
46
50
56
54
52
12
40
70
78
32
86
44
84
68
66
36
80
76
38
80
18
42
62
22
48
20
16
34
82
72
74
24
60
64
58
30
28

THERMAL INSULATING BUSHING FOR PISTON FIRST STAGES

FIELD OF THE INVENTION

This invention generally relates to a regulatory valve for use in a self-contained underwater breathing apparatus.

BACKGROUND OF THE INVENTION

Safely delivering breathable air to divers in a cold water environment presents challenges. Pressure regulators for underwater breathing convert high pressure gas to a lower pressure that are at or closer to a pressure that can be breathed by the diver.

First stage reduction of suitable gas for breathing typically incorporates pressure compensation for adjusting the pressure of the gas output from the pressure regulator based on the depth of the diver within the water. As a diver goes deeper in the water, the pressure compensation will increase the pressure of the gas being output from the regulator.

To provide pressure compensation, many regulators include a pressure compensation chamber that receives and fluidly communicates with the water surrounding the diver, and particularly the regulator. The water within the pressure compensation chamber will act on a moving mechanism that is biased in one direction by a spring and the ambient water and biased in an opposite direction by the gas being regulated and output by the regulator. As the surrounding water pressure increases, the force of the water on the moving mechanism also increases which creates an increased output pressure of the gas exiting the pressure regulator.

Unfortunately, the process of reducing the pressure of the gas from the inlet pressure to the outlet pressure is an adiabatic process that absorbs heat energy from the surrounding environment, namely the surrounding water.

In cold water dives, the temperature of the water can be near freezing. The adiabatic process of the pressure regulator can result in localized freezing of the surrounding water on the exposed surfaces of the regulator. If the water within the pressure compensation chamber freezes, the ice can affect the motion and operation of the moving mechanism and the spring.

The present invention seeks to provide improvements over the current state of the art of underwater pressure regulators for underwater breathing devices.

BRIEF SUMMARY OF THE INVENTION

In one aspect, the invention provides a first stage pressure regulator comprising a valve body that has an inlet and an outlet. The valve body defines a pressure chamber between the inlet and an outlet. The valve body further defines a pressure compensation chamber that has an opening. The opening fluidly communicates the pressure compensation chamber with the surrounding water.

The first stage pressure regulator further comprises a valve seat within the valve body and a valve member. The valve member is slidably carried within the valve body pressure chamber. The valve member has a valve end. An expansion head is connected to the valve end. The valve member is slidable between an open state and a closed state. In the open state the valve end is spaced from the valve seat and permits fluid flow between the inlet and outlet. In the closed state the valve end is sealingly seated against the valve seat to prevent fluid flow between the inlet and outlet. The expansion head is exposed to the pressure compensation

chamber and is operably acted upon by the surrounding water within the pressure compensation chamber to bias the valve member toward the open state.

The first stage pressure regulator is further comprised of an annular insulating bushing within the compensation chamber. The annular insulating bushing covers a portion of the valve body that defines a portion of the pressure compensation chamber. A biasing member is interposed between the annular insulating bushing and the expansion head to bias the valve member towards an open state.

The valve body defines an annular mounting groove that forms part of the pressure compensation chamber. The annular insulating bushing is positioned within the annular mounting groove.

The annular insulating bushing generally includes a base portion, an outer radial sidewall and an inner radial sidewall portion. The outer radial sidewall portion extends from the base portion. The inner radial sidewall portion extends from the base portion and radially inward of the outer radial sidewall portion. The base portion, inner radial sidewall portion and outer radial sidewall portion of the annular insulating bushing define an annular receiving groove that receives an end of the biasing member.

The annular mounting groove is defined by a radially outer surface portion, a base surface portion and a radially inner surface portion formed by the valve body. The outer radial sidewall portion overlaps with and insulates the radially outer surface portion from the water within the compensation chamber. The inner radial sidewall portion overlaps with and insulates the radially inner surface portion from the water within the compensation chamber. The base surface portion overlaps with and insulates the base portion from the water within the pressure compensation chamber.

The valve member of the first stage pressure regulator extends through and is concentric with the biasing member. The annular insulating bushing is formed from a thermal insulating plastic material. The portion of the valve body that is covered by the annular insulating material is formed from a metal material. The annular insulating bushing's inner radial sidewall portion has a first portion connected to the base portion that is generally parallel to the outer radial sidewall portion and a second portion that is canted relative to the first portion and defines the distal end of the inner radial sidewall portion. The canted portion is canted radially inward when moving away from the base portion.

In other embodiments the annular insulating bushing's inner radial sidewall portion has a first portion connected to the base portion that is generally parallel to the outer radial sidewall portion and a second portion that is canted relative to the first portion and defines the distal end of the inner radial sidewall portion. The canted portion is canted radially inward when moving away from the base portion. The radially inner surface portion has a first portion that is parallel to the radially outer surface portion and a second portion that is canted relative to the first portion to mate with the inner radial sidewall portion of the annular insulating bushing.

Another aspect of the present invention is directed toward a method of inhibiting the freezing of water within a pressure compensation chamber of a first stage pressure regulator. The first stage pressure regulator has a valve body having an inlet and an outlet. The valve body defines a pressure chamber between the inlet and an outlet. The valve body further defines a pressure compensation chamber. The pressure compensation chamber has an opening that fluidly communicates the pressure compensation chamber with the surrounding water. The first stage pressure regulator has a valve member slidably carried within the valve body pressure chamber that is slidable between an open and closed state. In the open state fluid is permitted to flow between the inlet and outlet. In the closed state fluid is prevented from flowing between the inlet and outlet. The valve member has an expansion head that is exposed to the pressure compensation chamber. The valve member is operably acted upon by the surrounding water within the pressure compensation chamber to bias the valve member toward the open state. The pressure regulator has a biasing member acting on the valve member to bias the valve member towards the open state.

The method comprises covering a portion of the valve body that defines a portion of the pressure compensation chamber with an annular insulating bushing positioned within the compensation chamber. The annular insulating bushing is sized and shaped to closely mate with the surfaces of the portion of the valve body that are covered by the annular insulating bushing. The valve body defines an annular mounting groove in which the annular insulating bushing is mounted. The step of covering includes covering the surfaces of the valve body that define the mounting groove with corresponding portions of the annular insulating bushing.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawing incorporated in and forming a part of the specification illustrates several aspects of the present invention and, together with the description, serves to explain the principles of the invention. In the drawing:

FIG. **1** illustrates an axial section of an embodiment of the valve according to the present invention with the valve member in an open position.

While the invention will be described in connection with certain preferred embodiments, there is no intent to limit it to those embodiments. On the contrary, the intent is to cover all alternatives, modifications and equivalents as included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates a first stage air pressure reduction valve **10** of a two stage system. The first stage air pressure reduction valve **10** may also be referred to as first stage pressure regulator **10** or even more simply as pressure regulator **10**. The first stage pressure regulator **10** is used to reduce the pressure of high pressure gas stored, typically, in a tank carried by a diver to a more manageable pressure that is used by a second stage regulator that supplies breathing gas to the diver.

The pressure regulator **10** generally includes a valve body **12**. In the illustrated embodiment, the valve body **12** is generally a two piece valve body having two components attached to one another. In this embodiment, the pieces are threadedly connected to one another.

The valve body **12** is joined to a supply of compressed air (not shown), such as a cylinder of compressed air, by of an inlet tubular union **14** attached to an inlet of the valve body **12**. The compressed air may be a mixture of oxygen and other suitable gases for cold water diving. For simplicity hereinafter the air or gas mixture will be referred to as gas.

The valve body **12** provides a pressure chamber **16** and a compensation chamber **18**. The pressure chamber **16** and compensation chamber **18** are concentric and coaxial. The pressure chamber **16** and compensation chamber **18** are separated from one another by a partition wall **20** and a valve member **22** that is movable.

The pressure chamber **16** communicates via the inlet tubular union **14** with the pressurized gas supplied into the pressure regulator **10** from the cylinder of compressed gas. The compensation chamber **18** communicates with the outside ambient water through openings **24** in the valve body **12**. During a dive, the compensation chamber **18** fills with water at a pressure corresponding to the dive depth.

The valve member **22** is slidingly carried within the valve body **12**. The valve member **22** has an expansion head **26** that is connected to a valve end **28** by a tubular stem **30**. The tubular stem **30** and expansion head **26** are both sealed to the valve body **12** to prevent ingress of ambient water or egress of the gas within the regulator. The tubular stem **30** and expansion head **26** are also allowed to slide axially within the valve body **12** as illustrated by arrow **32** so as to allow the pressure regulator **10** to reduce the pressure of the gas from its inlet pressure.

The tubular stem **30** is preferably a metal material such as stainless steel to ensure a better resistance both mechanically and chemically (saline, etc.). In this embodiment, the tubular stem **30** defines the valve end **28**.

The valve end **28** is tapered in the shape of a spout or funnel. The valve end **28** selectively seats against valve seat **34**. When the valve end **28** is spaced away from valve seat **34**, the pressure regulator is in an open state and gas is allowed to flow through the pressure regulator **10** from the inlet **14** to an outlet **36** of the pressure regulator **10**. This configuration is illustrated in FIG. **1**. When the valve end **28** is biased against the valve seat **34**, the fluid flow path between the inlet **14** and outlet **36** is closed preventing fluid flow.

The valve seat **34** is preferably of a non-metallic material so as to provide a good sealing engagement with the valve end **28** when the valve member **22** is in a closed state.

The expansion head **26** is at an opposite end of the valve member **22** and has an enlarged conical shape. This conical shape provides an enlarged area in which the gas is allowed to expand. The exterior surfaces of the expansion head are acted on by the water within the compensation chamber **18** to bias the valve member **22** toward the open state (e.g. in the direction of arrow **38**). The interior surfaces of the expansion head **26** are acted on by the gas sealed within the pressure regulator **10** to bias the valve member **22** towards the closed state (e.g. in the direction of arrow **40**).

A coil spring **42** is located within the compensation chamber **18** to bias the valve member **22** toward the open state (e.g. in the direction of arrow **38**) with a minimum predetermined amount of force. The coil spring **42** is interposed between the expansion head **26** and the valve body **12**, and particularly a portion of the partition wall **20**. The coils of the spring **42**, in this embodiment, are formed by a stainless steel core **44** covered by a thermal insulating material layer **46**.

The expansion head **26** of the valve member **22** communicates with the outlet **36** of the pressure regulator **10**. As gas flows from the inlet **14** to the outlet **36** through the valve member **22**, the gas is allowed to expand and drop in pressure. This expansion and pressure drop is an adiabatic process that draws heat energy out of the components of the pressure regulator **10** that surround the pressure chamber **16**, such as the valve body **12** and the valve member **22**.

Because of the adiabatic gas expansion, the compensation chamber **18** is subjected to a great temperature drop which can cause freezing of the water within the compensation chamber **18**. Ice formation within the compensation chamber **18** can affect the operation of coil spring **42**, valve member **22** or the openings **24** and inhibit the pressure compensation feature of the pressure regulator **10**.

One particular location where freezing occurs is proximate the end of the coil spring **42** that is pressed against the valve body **12**. To address the freezing problems within the chamber **18**, the illustrated embodiment includes a thermally insulating bushing **48** that covers the outer surfaces of the valve body **12** proximate the location where the coil spring **42** is supported.

The thermally insulating bushing **48** is interposed between the coil spring **42** and the valve body **12**. The thermally insulating bushing **48** is received in an annular mounting groove **50** defined by the valve body **12**. The annular mounting groove **50** is bound by portions of the valve body **12** including a base portion **52**, a first radially outer leg portion **54**, and a second radially inner leg portion **56** which combine to form a generally U-shaped cross-section. The thermally insulated bushing **48** seats within the annular mounting groove **50** against the exposed surfaces of the base portion **52**, radially outer leg portion **54** and the radially inner leg portion **56** and prevent exposure of the ambient water within the compensation chamber **18** to the potentially cold surfaces of the valve body **12** defining the mounting groove **50**.

The thermally insulated bushing **48** is shaped and sized to mate with the inner surfaces of the valve body that define annular mounting groove **50**. As such, the thermally insulated bushing **48** is annular and includes a bottom portion **58** that mates with the exposed surface of base portion **52**; a first radially outer sidewall portion **60** that mates with the exposed surface of the radially outer leg portion **54**; and a second radially inner sidewall portion **62** that mates with the radially inner leg portion **56**. The bottom portion **52** connects the sidewall portions **60**, **62** to one another. The sidewall portions **60**, **62** extend outward from a same side of the bottom portion **58**. The sidewall portions **60**, **62** are radially spaced from one another to form an annular receiving groove **64** that receives one end of coil spring **42**.

In the illustrated embodiment, the radially outer sidewall portion **60** is a generally straight member. The radially inner sidewall portion **62** has two sections including a straight section **66** and a conical section **68** that is tapered relative to the straight section. The straight section **66** is interposed between the conical section **68** and the bottom portion **58**. These portions mate with corresponding portions of the exposed surface of the radially inner leg portion **56**.

The thermally insulated bushing **48** may be press fit, friction fit, glued, or mechanically secured within the annular mounting groove **50**.

The thermally insulated bushing **48** is preferably made of thermal insulating plastic material, which can also include a suitable filling material, such as for instance empty microspheres embedded in the plastic to improve the thermal insulation and inhibit heat transfer from the water within the compensation chamber to the valve body **12** and pressure regulator **10**, generally. The thermally insulated bushing **48** attempts to force the adiabatic expansion process to draw heat energy from a different location and source of energy other than the water within the compensation chamber **18**.

Additional insulation may be provided by thermally insulating the annular part **70** of the expansion head **26** that is acted upon by the water within the compensation chamber **18**. The annular part **70** of the expansion head **26** carries on its outer radial periphery a first watertight main ring (O-ring) **72** and a second ring **74**. Lubrication is provided in the compartment formed between said rings **72** and **74** and the side wall **76** of the compensation chamber **18**.

A threaded bushing **78** is provided to hold together the annular part **70** to the stem **30**. The threaded bushing **78** is screwed to stem **30**, which is externally threaded as well. Moreover, a further watertight ring **80** is interposed between the threaded bushing **78** and the stem **30**. Main watertight ring **72** is set in a groove **82** having a width greater than that of the ring **72** itself, so that it is slightly movable relative to the expansion head **26** when performing its opening or closing stroke, further improving the lubrication of the parts in motion. Alternative embodiments may use a single O-ring. In yet other embodiments, threaded bushing **78**, annular part **70** and stem **30** may be formed from one or more pieces.

In addition to the insulation provided by annular part **70**, stem **30** is provided with thermal insulation means comprised of sheath **84** on the stem **30** before the threaded section of the stem **30**, made of compressible thermally insulating material. When the valve member **22** is in its open state the sheath **84** is stretched in its natural position, while when the valve member **22** is in a closed position the sheath **84** is compressed. Additional insulation is provided with a further bushing **86** of thermal insulating material placed around the threaded bushing **78** and projecting against the annular part **70** of the expansion head **26** of the valve member **22**.

Because of the thermally insulated bushing **48** and the other described insulating means, heat transfer from the water within the compensation chamber **18** is reduced which inhibits freezing of the water within the pressure compensation chamber **18** during cold water dives, at least for the length of time of a normal diving, thus avoiding the inefficiency or the eventual valve blocking and the connected risks for the user. Further, with thermal insulated bushing **48** insulating in cooperation with bushing **86**, threaded insulated bushing **78** insulating material layer **46** and sheath **84** the surfaces exposed to the ambient water (also referred to as the "wet area") of compensation chamber **18** are substantially insulated. In some embodiments more than 80% of the surfaces in compensation chamber **18** are insulated and in yet other embodiments at least 90% of the surfaces in compensation chamber **18** are insulated.

All references, including publications, patent applications, and patents cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) is to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. A first stage pressure regulator comprising:

a valve body having an inlet and an outlet and defining a pressure chamber between the inlet and the outlet, the valve body defining a pressure compensation chamber having an opening fluidly communicating the pressure compensation chamber with a surrounding water;

a valve seat within the valve body;

a valve member slidably carried within the valve body pressure chamber having a valve end and an expansion head connected to the valve end, the valve member slidable between an open state in which the valve end is spaced from the valve seat and that permits fluid flow between the inlet and outlet and a closed state in which the valve end is sealingly seated against the valve seat and that prevents fluid flow between the inlet and outlet, the expansion head being exposed to the pressure compensation chamber and being operably acted upon by the surrounding water within the pressure compensation chamber to bias the valve member toward the open state;

an annular insulating bushing within the compensation chamber and covering a portion of the valve body defining a portion of the pressure compensation chamber; and

a biasing member interposed between the annular insulating bushing and the expansion head to bias the valve member towards the open state.

2. The first stage pressure regulator of claim **1**, wherein the valve body defines an annular mounting groove that forms part of the pressure compensation chamber, the annular insulating bushing being positioned within the annular mounting groove.

3. The first stage pressure regulator of claim **2**, wherein:

the annular insulating bushing generally includes a base portion, an outer radial sidewall portion extending from the base portion, an inner radial sidewall portion extending from the base portion and radially inward of the outer radial sidewall portion;

the base portion, inner radial sidewall portion and outer radial sidewall portion defining an annular receiving groove that receives an end of the biasing member.

4. The first stage pressure regulator of claim **3**, wherein:

the annular mounting groove is defined by a radially outer surface portion, a base surface portion and a radially inner surface portion formed by the valve body;

the outer radial sidewall portion overlapping with and insulating the radially outer surface portion from the water within the compensation chamber;

the inner radial sidewall portion overlapping with and insulating the radially inner surface portion from the water within the compensation chamber; and

the base surface portion over lapping with and insulating the base portion from the water within the pressure compensation chamber.

5. The first stage pressure regulator of claim **1**, wherein the valve member extends through and is concentric with the biasing member.

6. The first stage pressure regulator of claim **1**, wherein the annular insulating bushing is formed from a thermal insulating plastic material.

7. The first stage pressure regulator of claim **1**, wherein the portion of the valve body that is covered by the annular insulating material is formed from a metal material.

8. The first stage pressure regulator of claim **3**, wherein the inner radial sidewall portion has a first portion connected to the base portion that is generally parallel to the outer radial sidewall portion and a second portion that is canted relative to the first portion and that defines the distal end of the inner radial sidewall portion.

9. The first stage pressure regulator of claim **8**, wherein the canted portion cants radially inward and extends in a direction away from the base portion towards the outlet.

10. The first stage pressure regulator of claim **4**, wherein the inner radial sidewall portion has a first portion connected to the base portion that is generally parallel to the outer radial sidewall portion and a second portion that is canted relative to the first portion and that defines the distal end of the inner radial sidewall portion.

11. The first stage pressure regulator of claim **10**, wherein the canted portion cants radially inward and extends in a direction away from the base portion towards the outlet.

12. The first stage pressure regulator of claim **11**, wherein the radially inner surface portion has a first portion that is parallel to the radially outer surface portion and a second portion that is canted relative to the first portion to mate with the inner radial sidewall portion of the annular insulating bushing.

13. A method of inhibiting freezing of water within a pressure compensation chamber of a first stage pressure regulator, the first stage pressure regulator having a valve body having an inlet and an outlet, the valve body defining a pressure chamber between the inlet and an outlet, the valve body defining the pressure compensation chamber and having an opening fluidly communicating the pressure compensation chamber with the surrounding water, the first stage pressure regulator having a valve member slidably carried within the valve body pressure chamber slidable between an open state in which fluid is permitted to flow between the inlet and outlet and a closed state in which fluid is prevented from flowing between the inlet and outlet, the valve member having an expansion head being exposed to the pressure compensation chamber and being operably acted upon by the surrounding water within the pressure compensation chamber to bias the valve member toward the open state, the pressure regulator having a biasing member acting on the valve member to bias the valve member towards the open state, the method comprising:

covering a portion of the valve body defining a portion of the pressure compensation chamber with an annular insulating bushing positioned within the compensation chamber.

14. The method of claim **13**, wherein the annular insulating bushing is sized and shaped to closely mate with the surfaces of the portion of the valve body that are covered by the annular insulating bushing.

15. The method of claim **14**, wherein the valve body defines an annular mounting groove in which the annular insulating bushing is mounted, the step of covering including covering the surfaces of the valve body that define the mounting groove with corresponding portions of the annular insulating bushing.

* * * * *